Improvement in Student Achievement through a Flipped Database Management Classroom: Shifting from Passive Traditional to Active Learning

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Abstract—The current study aimed to investigate the effect of using the flipped classroom instructional method on students' academic achievement compared to the traditional instructional method. The data were collected from 52 undergraduate male and female students enrolled in a course in database management at a Jordanian public university. The results of 2-way ANOVA revealed a statistical significance main effect on students' overall achievement due to the flipped classroom instructional method. The results of 2-way ANCOVA also revealed a statistical significance main effect on students' overall achievement due to the flipped classroom instructional method after controlling for each of the student's GPA, and the student's average interaction covariates.

Keywords—flipped classroom, academic achievement, database management

1 Introduction

New technologies have resulted in a progressive change in teaching in higher education recently. The instructor-based teaching model is either combined or replaced with other active and student-oriented models. Progressive evolution and emerging new technologies and approaches are supporting this change through a variety of digital resources. The flipped classroom instructional method is considered an effective learning model among these active learning models. This model helps students to participate in the active learning process with better interactions with the instructor and among themselves [1].

The flipped classroom model emerged as a methodology of combining face-to-face and online teaching, where students handle the study materials outside the classroom, spending much more time in class on problem-solving and interactive activities [2]. The instructor usually prepares and uploads the content in a multimedia format (usually audio-visual videos) on cloud platforms to be accessible from anywhere [3]. In this way, practical learning mediated by technology takes place [4] which provides more active educational opportunities for students. Bergmann and Sams [5] address several features of the flipped classroom model, where students can learn at any time and any place and meet individual differences among the students.

Academic achievement is a representation of the ability of students to attain a set of corresponding learning outcomes [6], and demonstrates competencies in extracurricular activities [7]. Improving academic achievement represents the main interest of educational institutes and attracts many researchers to examine and apply various new educational technologies.

2 Aim of the study

The problem addressed in this study stems from the need to diversify the instructional methods and technologies used for undergraduate students, particularly in the database management course where a low level of achievement is usually observed. Database management course requires additional tools and explanations for students at such advanced levels, students are diverse and several teaching methods and multimedia are required. Lack of time in the class prevents students from understanding the abstract course concepts according to their individual differences. Additionally, senior students have a crowded timetable and stress due to their final year project and passing issues in all courses. Therefore, the current study aimed to investigate the effect of the flipped classroom instructional method compared to the traditional instructional method on the student's academic achievement. To achieve this objective, the study sought to answer the following question:

1. Are there significant differences in the student's academic achievement due to the instructional method, student gender, and the interaction between the instructional method and student gender?
2. Are there significant differences in the student's academic achievement due to the instructional method, student gender, and the interaction between the instructional method and student gender after controlling for the student's grade point average (GPA)?
3. Are there significant differences in the student's academic achievement due to the instructional method, student gender, and the interaction between the instructional method and student gender after controlling for the student's average interaction?

3 Related work

Several researches addressed the potential impact of the flipped classroom instructional model and its ability to improve student's achievement as measured by student grades in various disciplines including mathematics, foreign languages, science, medicine, and engineering [8–22]. The flipped instructional model helps students prepare for classes and exams, and this preparation is reflected in their academic performance [23]. Studies such as [24] and [25] investigated the effectiveness of the flipped learning according to exam scores which results in improved higher scores than those obtained by traditional learning. The result in [26] revealed a significant improvement in the learning level and a positive perception of students by flipped learning for students in communication systems. However, more investigation with precise environmental variables are required to address how the different aspects of the flipped learning model can be moderated [27].

Focusing attention more specifically on the computer sciences field, several higher education-related courses are seeking to enhance student learning by applying flipped classrooms in various computing courses and comparing flipped and traditional instructional approaches [28]. The flipped learning methods were applied to the different computing subjects teaching [29] mainly for; introductory programming [30], databases [31], object oriented programming [32], computer algorithms [33], information technology [34, 35], and software engineering [36].

The authors in [31] conducted a study addressing the database course using the flipped classroom model, and the findings indicated a positive effect of this model in improving the student's achievement. The authors assert that students attain more focus on precise learning objectives during the critical class time, and obtain better understanding of database by flipping instructional method. A study in [37] compared traditional to WeChat-based flipped instructional model for teaching Structured Query Language. The sample was divided into an experimental group (N = 50) taught by the flipped classroom instructional method and a control group (N = 44) taught by the traditional instructional method. It was found that the achievement of experimental group was significantly better than the other group. This presents empirical evidence about the ability of flipped instructional methods to improve higher education achievement. Yang et al., in [38] analyzed the sophomore undergraduate students' online learning behavior and their learning performance in flipped classes in a database system course. They found that watching lecture videos in a flipped classroom gives rise to better learning outcomes if a wisely arrange online learning plan is adopted.

4 Method

4.1 Participants

The sample consisted of 52 undergraduate students (63.5% males, and 36.5% females) distributed equally into two groups (flipped classroom instructional method, traditional instructional method) such that each group consisted of 26 students. Students in both groups are enrolled in a course on database management that is offered by the information technology college at a public university in Jordan. Students were randomly assigned to both groups, and both groups were taught by the first author in the summer semester of the 2020/2021 academic year. Two students in the experimental group (flipped classroom instructional method) dropped out of the course leaving out 24 students in this group.

4.2 Instruments

Two instruments were used in assessing the students' overall achievement grades in the course i.e., the midterm test and the final exam. The midterm test was composed of 20 multiple-choice items and two scenarios as each scenario weights five points, whereas the final exam was composed of 30 multiple-choice items and four scenarios as each scenario weights five points. The items of both tests were selected purposefully from an item bank constructed by the author of the course textbook. The item bank construction was based on the course objectives as each objective was assessed by several

items varied in difficulty level. The content validity of both tests was evaluated by presenting them to two colleagues who had previous experience in teaching the course. The stratified Alpha method was used to evaluate the reliability of each test. The stratified Alpha coefficient of the midterm test was found to be .880, whereas it was .910 for the final exam. The midterm test weighs 30 points of the composite final grade, while the final exam weighs 50 points.

4.3 Procedures

The participants were randomly assigned to two groups: the experimental group (flipped classroom instructional method) and the control group (traditional instructional method). The flipped classroom instructional method was based on sending video-recorded lectures to the students prepared prior to face-to-face classroom activities and discussions delivered via Moodle platform. In the face-to-face lectures, the instructor meets with the experimental students in the classroom and reviews with them the content of the recorded lectures and conducts several active learning activities e.g. discussions, questions and answers. The traditional instructional method was based on teaching the students in-classroom face-to-face lectures; assigning them homework that is delivered on the Moodle platform and correcting it, and returning it to the students for discussion in the upcoming meetings. The student's overall achievement grade was calculated by combining the student's midterm test score, final exam score, and semester works score. The semester works score weighs 20 points of the final grade and it represents a weighted composite of homework assignments, in-classroom activities, discussions, quizzes, and participation. The design of the study includes two covariates: the student's GPA which was obtained from the department of admission and registration in the university, and the student's average interaction with activities was evaluated by the course instructor i.e., the first author.

5 Results

Descriptive measures of participants' overall achievement grades in each instructional method were calculated along with student gender and presented in Table 1.

Table 1. Descriptive measures of the participants' overall achievement grades

Gender	Instructional Method	N	M	SD
Male	Flipped Classroom	14	61.071	11.262
	Traditional	18	52.388	12.281
	Total	32	56.187	12.452
Female	Flipped Classroom	10	59.700	12.570
	Traditional	8	41.500	8.088
	Total	18	51.611	14.042
Total	Flipped Classroom	24	60.500	11.575
	Traditional	26	49.038	12.130
	Total	50	54.540	13.093

It was observed from Table 1 that the mean score of the experimental group's (flipped classroom instructional method) overall achievement (M = 60.500) exceeds that of the control group (traditional instructional method) (M = 49.038) irrespective of the student's gender. It was also observed that the male's overall achievement (M = 56.187) exceeds the female's overall achievement (M = 51.611) irrespective of their group. On the other hand, it was observed that the males (M = 61.071) outperformed the females (M = 59.700) in the experimental group (flipped classroom instructional method). Similarly, the findings revealed that the males (M = 52.3880) outperformed the females (M = 41.500) in the control group (traditional instructional method).

A 2-way factorial analysis of variance (2-way ANOVA) was performed to examine the main effect of each independent variable; the instructional method and gender, and the interaction effect between both independent variables on the dependent variable i.e., the student's academic achievement. The data had no outliers, as assessed by inspection in boxplots. The scores for each level of the instructional method were normally distributed, as assessed by the Shapiro-Wilks test ($p = .277, .194$) for the experimental and control groups respectively. Levene's test for equality of variances ($p = .637$) didn't violate the homogeneity of variances. No statistically significant differences in the student's academic achievement were observed due to the interaction effect between the instructional method and gender ($F(1, 46) = 1.943, p = .170$). In contrast, while the results indicated a statistically significant main effect of the instructional method on the student's academic achievement ($F(1,46) = 15.500, p < .001$) in favor of the experimental group i.e., the flipped classroom instructional method with a large effect size (Partial $\eta^2 = .252$), no statistically significant main effect due to gender was observed on the student's academic achievement ($F(1,46) = 3.224, p = .079$). The results are presented in Table 2.

Table 2. Results of 2-way ANOVA to determine the main effect of the instructional method and gender, and their interaction effect on the student's academic achievement

Source	Type III SS.	DF	MS.	F. Value	Sig.	Partial η^2
Instructional Method	2053.135	1	2053.135	15.500	.000	.252
Gender	427.052	1	427.052	3.224	.079	.065
Instructional Method*Gender	257.347	1	257.347	1.943	.170	.041
Error	6093.306	46	132.463			
Total	157131.000	50				

A 2-way analysis of covariance (2-way ANCOVA) was performed to investigate whether the academic achievement mean scores differed due to the main effect of each independent variable i.e., the instructional method, gender, as well as the interaction effect between both independent variables while controlling for the student's GPA as a covariate. The data had no outliers, as assessed by inspection in boxplots. The scores for each level of the instructional method were normally distributed, as assessed by the Shapiro-Wilks test ($p = .277, .194$) for the experimental and control groups respectively. Levene's test for equality of variances assumption indicated homogeneity of variances among groups ($p = .288$). The results are presented in Table 3.

Table 3. Results of 2-way ANCOVA to determine the main effect of the instructional method and gender, as well as their interaction effect on the student's academic achievement after controlling for the student's GPA

Source	Type III SS.	DF	MS.	F Value	Sig.	Partial η^2
GPA	609.010	1	609.010	4.997	.030	.100
I. Method	720.839	1	720.839	5.915	.019	.116
Gender	407.250	1	407.250	3.342	.074	.069
I. Method*Gender	163.531	1	163.531	1.342	.253	.029
Error	5484.297	45	121.873			
Total	157131.000	50				

The results presented in Table 3 indicated no statistically significant interaction effect between the two independent variables; instructional method and gender on the student's academic achievement ($F_{(1, 45)}$ = .193, p = .662). The results also revealed no statistically significant gender main effect on the student's academic achievement ($F_{(1,45)}$ = 2.387, p = .129), whereas a statistically significant main effect with a large effect size (Partial η^2 = .205) of the instructional method on the student's academic achievement was observed ($F_{(1,45)}$ = 11.569, p = .001) after controlling for the student's GPA when ignoring (averaging over) the levels of gender i.e., taking gender into account as a whole, but ignoring whether a participant was male or female. In other words, there is a difference in the student's academic achievement after adjusting for the student's GPA between participants who underwent the flipped classroom instructional method and their counterparts who underwent the traditional instructional method when ignoring the student's gender in favor of the experimental group i.e., the flipped classroom instructional method. The adjusted mean score of the flipped classroom method was 59.037, whereas it was 49.049 for the traditional instructional method after controlling for the GPA covariate.

Similarly, a 2-way ANCOVA was performed to determine the main effect of each independent variable i.e., the instructional, gender, as well as the interaction effect between both variables on the dependent variable i.e., the student's academic achievement after controlling for the student's average interaction as a covariate. The data had no outliers, as assessed by inspection in boxplots. The scores for each level of the instructional method were normally distributed, as assessed by the Shapiro-Wilks test (p = .277, .194) for the experimental and control groups respectively. Levene's test for equality of variances assumption indicated homogeneity of variances among groups (p = .423). The results are presented in Table 4.

Table 4. Results of 2-way ANCOVA to determine the main effect of the instructional method and gender, and their interaction effect on the student's academic achievement after controlling for the student's average interaction

Source	Type III SS.	DF	MS.	F Value	Sig.	Partial η^2
Av. Interaction	609.010	1	609.010	4.997	.030	.100
I. Method	720.839	1	720.839	5.915	.019	.116
Gender	407.250	1	407.250	3.342	.074	.069
I. Method*Gender	163.531	1	163.531	1.342	.253	.029
Error	5484.297	45	121.873			
Total	157131.000	50				

The results presented in Table 4 indicated no statistically significant interaction effect between the instructional method and gender on the student's academic achievement ($F_{(1, 45)}$ = 1.342, p = .253). The results also revealed no statistically significant gender main effect on the student's academic achievement ($F_{(1,45)}$ = 3.342, p = .074), whereas a statistically significant main effect with a mediocre effect size (η^2 = .116) of the instructional method on the student's academic achievement ($F_{(1,45)}$ = 5.915, p = .019) after controlling for the student's average interaction variable when ignoring (averaging over) the levels of gender i.e., taking gender into account as a whole, but ignoring whether a participant was male or female. In other words, there is a difference in the student's academic achievement after adjusting for the student's average interaction between participants who underwent the flipped classroom instructional method and their counterparts who underwent the traditional instructional method when ignoring the student's gender in favor of the experimental group i.e., the flipped classroom instructional method. The adjusted mean score of the flipped classroom method was 58.258, whereas it was 49.055 for the traditional instructional method after controlling for the student's average interaction covariate.

6   Discussion

The findings of the current study were in line with the previous findings of the various studies that addressed the impact of the flipped classroom instructional method compared to the traditional instructional method. The results of the present study revealed that students achieved higher grades in the experimental group i.e., flipped classroom instructional method compared to the control group i.e., traditional instructional method, and this is congruent with the findings of several studies such as [31], [37], [39], [40], [41] in which all have indicated that using flipped classroom learning model could enhance students' academic performance.

The high performance of the experimental group could be attributed to the advantages of technology and multimedia in providing information through the flipped classroom instructional method. The advantages of the flipped classroom instructional method are computerized materials, learning method, learner-computer interaction, location, and time advantage [42] may have contributed to the better performance of the students in the experimental group. Moreover, it can be attributed to the design of the learning materials that are designed using computerized multimedia to be attractive, engaging, and enjoyable for students, and contain sight and sound features that far outweigh the rigid drawings in the textbook thus making learning more fun. The materials were also recorded and available for students through any mobile or computer device at home and without in-class time restrictions so that students can study repeatedly and obtain ideas. This can also be attributed to the novelty in the style of introducing lessons via computer multimedia. In addition to the distinctive advantages of the flipped classroom method that significantly improved the students' achievement in the experimental group, we argue that the students at this educational level (senior students) prefer using e-materials that contain sight and sound features and watching videos for learning. Finally, in addition to reinforcing all features of the flipped classroom instructional method as was revealed by the current findings, it can be concluded that this method contributes to grasping students' concentration, engaging students in in-class tasks, and understanding ambiguous and abstract themes.

7   Conclusion

The current study aimed to determine the effect of using the flipped classroom instructional method as compared with the traditional instructional method on the student's academic achievement. It can be concluded from the findings of the present study that the flipped classroom instructional method is effective compared to the traditional method. It can also be concluded that using the flipped instructional method can improve the student's academic achievement. While we recommend using the flipped classroom instructional method, its effect might be limited to specific subjects and settings. Therefore, more studies are needed to examine the effect of using the flipped classroom instructional method in various subjects and settings. Moreover, it is recommended to compare the effect of using the flipped classroom instructional method with other instructional methods rather than the traditional method. It is also worth recommended to examine the effect of this method on different student attributes such as self-efficacy, academic self-concept, and self-confidence. We can conclude that the flipped classroom model has meant a paradigm shift in the teaching-learning process. We argue that the traditional instructional method must be enriched and improved to be more useful inside and outside the classroom and allow to access e-resources easily. Flipped classroom method provides an opportunity for the students to learn at their own pace and repeatedly, and to learn according to their differences to gain a better understanding of abstract concepts of the subject. Because students are reluctant to participate and collaborate outside the class, and miscommunicating with students outside the class are some challenges that need to be addressed. Finally, although the findings obtained in this study are satisfactory, we recognize our small sample size as

a limitation of the study. Hence, future researchers may wish to replicate this study on a larger scale. Future studies could also aim to test, compare and contrast, in similar or dissimilar settings. Replicating this study in settings other than the database management course is also recommended.

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